Mechanical characterization of membranes by oscillatory electrodeformation of vesicles

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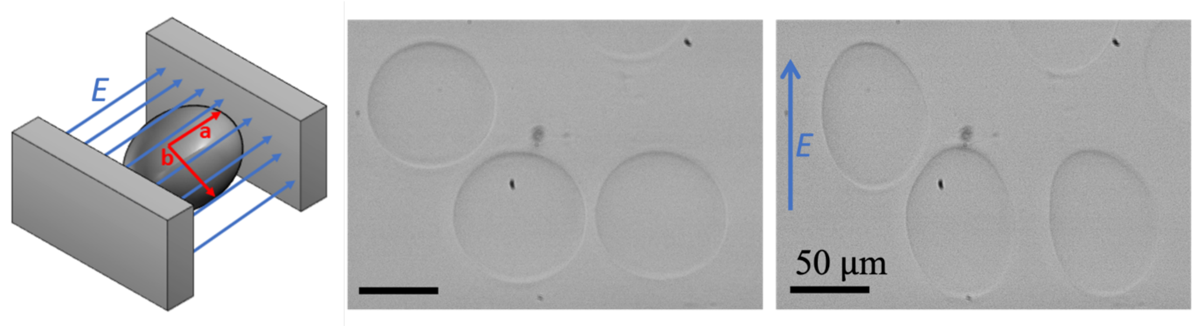
Cell membranes exhibit dramatic morphological changes during cell growth, division or endocytosis. A peculiar combination of membrane elastic properties facilitates such processes during cell life. To understand the origin of this singular mechanics, synthetic membranes with increasingly complex compositions are conventionally used as minimal membrane models to assess membrane mechanical properties by several different methods. Unfortunately, despite there is a considerable amount of data collected on membrane mechanical properties, there are apparent discrepancies among techniques and groups, which demands further attention.[1] In this project, we will characterize the mechanical properties of synthetic membranes with enhanced precision based on two key methodological improvements. On the one hand, our synthetic membranes, shaped as vesicles, will be fabricated using microfluidic technologies, which provide unprecedent control on membrane and internal composition.[2] Conventional methods for vesicle production rely of the self-assembly of amphiphiles in an aqueous environment, which yields vesicles with polydisperse size, inhomogeneous compositions and low encapsulation efficiencies, mainly due to the random nature of such self-assembly process. Directing the assembly of the amphiphiles using double emulsion drops, fabricated with microfluidic devices, overcomes these major drawbacks, which is likely an important source for the discrepancies on membrane mechanical properties. On the other hand, the project aims at developing a novel oscillatory vesicle micro-rheometer for the simultaneous determination of membrane elasticity and viscosity at high throughput, extending previously reported electrodeformation techniques.[3] Importantly, in addition, the proposed oscillatory technique will provide the dependence of such mechanical properties on deformation frequency, which will significantly impact our understanding on vesicle membrane dynamics.



Schematic illustration and bright field optical microscope images showing the deformation of spherical vesicles, produced by microfluidics, into prolate ellipsoids elongated along the direction of the applied AC electric field.

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[1] Dimova R. Recent developments in the field of bending rigidity measurements on membranes. *Adv. Colloid Interf. Sci.* **2014**, 208: 225-234.

[2] a) Arriaga LR, *et al*. Ultrathin shell double emulsion templated giant unilamellar vesicles with controlled microdomain formation. *Small* **2014**, 10: 950; b) Arriaga LR, *et al*. Single-step assembly of asymmetric vesicles. *Lab Chip* **2019**, 19: 749.

[3] a) Dimova R, et al. Vesicles in electric fields: Some novel aspects of membrane behavior. *Soft Matter* **2009**, 5: 3201; b) Faizi HA, Dimova R, Vlahovska PM. A vesicle microrheometer for high-throughput viscosity measurements of lipid and polymer membranes. *Biophys. J.* **2022**, 121: 910.